RESEARCH HIGHLIGHTS

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SAFE HOUSING FOR LIGHTLY CONTAMINATED LANDS

Introduction

Abandoned urban industrial lands are being redeveloped for housing, many with residual contamination on the site. Developers, environmental consultants, and regulatory bodies often use site specific risk assessments to determine the degree of risk to occupants due to the unremoved contaminants. Risk assessments predict the potential exposure to contaminants that residents of the buildings will face, and the risks due to these exposures. The assessments can vary widely from one consultant to another (see the CMHC report *Evaluation of Site-specific Risk Assessment for Contaminated Lands*). The real proof of a successful site design and remediation would include measurement of pollutant levels in the buildings after their completion, particularly if the monitoring period is long enough to catch seasonal variations.

The research project, *Safe Housing of Lightly Contaminated Lands*, is the culmination of a series of CMHC research into houses on contaminated sites. CMHC has investigated the success of remedial measures in two previous studies (Study of Houses Affected by Hazardous Lands [1992], Field Tests of Remedial Measures for Houses Affected by Hazardous Lands [1995]). That survey work was retrospective, based on projects already complete, and the research suffered from a lack of data. None of the cases investigated included risk assessments with predicted pollutant levels. At the time of that research, generally several years after the buildings had been erected or remediated, the reasons for requiring soil gas protection were often not on record. Most of the examples dealt with methane intrusion problems. The data justifying the need for occupant protection was often missing, badly recorded, or lacking credibility. Many of the buildings, despite having soil gas protection measures installed, had no monitoring of contaminant levels following the remedial measures. In some cases, the measures themselves, such as sub-slab exhaust fans, were allowed to degrade or were shut off some time after their installation, although clearance testing had not been undertaken by any regulatory agency. The 1995 CMHC research project, in which pollutant levels were measured on site, showed few levels of concern in the houses. The main reasons for the low pollutant levels in these four groups of houses were the low levels of the contaminant in the soils and soil types that restricted soil gas movement.

The perception of risk with contaminated lands has moderated since the early 1990s. Developers and regulators now recognize risks due to contaminants in the soil, but are more apt to see these risks as manageable and in line with other health or financial risks that are encountered in construction. Provincial authorities now permit site specific risk assessments, rather than depending solely on generic soil criteria. As a result, more developments are taking place on inner city lands. The current project was designed to establish whether potential risks to occupants from subsurface contaminants is being handled well in these developments.

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Research Program

The research consultant was asked to :

1. Locate three developments where housing was being built on sites known to have had soil contamination, and where site specific risk assessment procedures were used to reduce soil cleanup costs;
2. Negotiate with developers, municipal and provincial regulatory agencies, and homeowners so that predicted contaminant levels could be recorded, and obtain access to occupied residences;
3. Measure contaminant levels in representative buildings; and
4. Report on the results of this research to CMHC, the cooperating agencies, and homeowners.

Unfortunately, the consultant was not able to locate three sites with cooperative environmental contractors and willing building owners. The first case, a high rise along Vancouver's shoreline, met all the above criteria. The next case, clean-up of arsenic laden tailings and the implications on housing in Wells, B.C., was competently undertaken but no new houses had been constructed on the site as the research required.

The consultant then spent parts of the next four years looking for an elusive third site. Some residential developments are being planned or built on contaminated soils. However, it was impossible to convince the owners or developers of these projects that the research project had value for them. As it stood, there is little indoor air quality monitoring that takes place following construction. Builders and developers do not know if their houses are meeting the low pollutant concentrations suggested by the risk assessments.

Results

Pacific Place, Vancouver BC

Residential development on the old Expo'86 site in Vancouver was built over contaminated soils. Previous use of the site included an oil-gasification plant, railyards, and a small landfill. Contaminants of concern included polycyclic aromatic hydrocarbons, benzene, toluene, and heavy metals. The remediation plan specified removal of zones of high contamination and capping soils with high metal contents. This case study concerns an apartment erected on this site, which is built over a three level parking garage. Residents were protected from the soil contaminants through the excavation of soils with coal tar contents, the use of membranes as protection of the foundation against groundwater and soil gas entry, and careful design of sumps and collection drains to minimize soil gas entry. The parking garage is ventilated during periods of high vehicular usage. The fan is also activated by elevated carbon monoxide concentrations or high levels of combustible gases.

A risk assessment of this site concluded that there would be no significant soil gas migration and intrusion, and that human exposure from these sources would be negligible. To verify this assessment, the current research project checked for:

1. Concentrations of volatile organic compounds (VOC) in the water in sumps and in soil gases.
2. A comparison of VOC concentrations in sump water and soil gas with those found in the indoor air.
3. Detailed gas intrusion monitoring or modelling, if necessary.

In June through September of 1998, the water in sumps and the air above the water were analyzed for VOCs. All tests were near or below the photoionization detector limit. Tests in October showed measurable amounts of VOCs in the soil gases and parkade air. Typically, the concentrations were equivalent (in both soil gas and parkade air) to VOC concentrations that were found in a Health Canada survey of 757 houses (reported in 1996), and between 2-100 times higher (depending upon the VOC) than the ambient air concentrations outside. Results for a few VOCs may have been tainted by recent line painting in the garage levels. Essentially, the VOC concentrations above or below the slab were not markedly above recorded residential values. The fact that parkade and soil gas concentrations were equivalent suggests that soil gases would not be a significant contributor to parkade and hence residential concentrations.

To confirm these findings, the consultant used a procedure previously developed for CMHC (A Guide for Estimating Indoor Concentrations of Soil Gas Pollutants in Housing, Figley 1997). The procedure estimates pressure differences across the slab and crack areas, and then calculates soil gas entry rates. Using this procedure, the consultants estimated that soil gas entry rates were in the order of 2.5 m^3/h. At this entry rate, soil gas influx would barely raise the parkade air VOC concentrations due to the amount of dilution air that flows through the parkade.

The simulations were followed up by measured pressures and flows. With pressures in the parkade lower than outdoors due to either exhaust fan or stack effects, the consultant measured small pressure differences across the slabs, in the order of 0-2 Pa of positive pressure from the soil. In December 1998, they injected helium as a tracer gas into the soil and calculated the soil gas entry rate from into the parkade from the measured concentrations in the parkade. The calculated soil gas entry rate from the tracer gas results was about 0.2 m^3/h, or about 10 times lower than the theoretical rate of 2.5 m^3/h determined from the CMHC calculation procedure cited above.

How did the findings compare to the risk assessment? There is a small, but measurable, influx of soil gases into the parkade. The contribution of soil gas VOC to the parkade concentrations is low because of the amount of dilution air infiltrated into the parkade or induced by parkade exhaust fans. As well, contaminant concentrations in the soil gases were very low in the samples taken. There is a further dilution when parkade gases are infiltrated into the living areas above. This factor was not measured in the study. The findings confirm that exposure to contaminated soil gases is not a significant exposure pathway for residents.

Wells, B.C

The Wells site met some of the criteria for this study. Wells had gold mining and ore processing locally for over 50 years. Tailings high in arsenic had been used as fill within the residential community. An investigation and clean-up was undertaken by the B.C. Ministries of Health and Environment. It was completed in 1993. The clean-up criteria for arsenic in soil was set at 150 µg/g. Following the remediation, a consultant was retained to conduct a quantitative assessment for risks posed by arsenic in various media to residents of Wells. The primary purpose of the assessment was to determine the risk levels to residents exposed to town soils containing arsenic concentrations between 30 and 150mg/g (Golder 1993). The consultant assessed 16 different exposure scenarios to arsenic (e.g., inhalation of house dust, soil ingestion, ingestion of groundwater, etc.). Based on all exposure pathways, the conclusion of the study was that the non-cancer risk to residents of Wells was negligible and the incremental lifetime cancer risk (ILCR) for residents was acceptable based on the provincial environmental policy level of $7x10^{-6}$. The pathways driving risk were fugitive dust inhalation and lake-side tailings ingestion.

The current CMHC study intended to show whether houses adjacent to the highest concentrations of tailings, particularly new houses, were adequately protected by the clean-up criteria. Is the arsenic exposure of occupants of these houses excessive, or is it still within the limits of risk set by the BC government study? The desire of CMHC particularly to assess the performance of new houses was thwarted by the lack of new houses in Wells. Only 10 houses had been constructed in the community between the first and second studies, with only two in the target area. The residents of these two houses declined to participate in the 1999 research.

A total of 22 houses were identified as being in proximity to the remediated area, and residents of 15 of those houses agreed to participate in the study. Dust was collected from vacuum cleaner bags of fifteen houses and also by a specialized vacuum (HVS3) in four houses. Results from three of the fifteen houses were somewhat suspect as major home or yard renovations were in progress. As well, two of the residents ran hospitality-based businesses in their houses, somewhat distorting the residential nature of the study. The table below compares the dust and soil concentrations from the 1993 and the 1999 assessments. The reduced sample does not include the three houses with businesses or recent major renovations.

µg/g	1993	1999 full sample	1999 reduced sample
Mean arsenic in soil	25	32.8	34.6
Soil arsenic range	NA	9-150	11-150
Mean arsenic in house dust	10.5	29.9	19.5
House dust range	3.3-31.9	12-200	12-40

There are several reasons why the 1999 house dust samples could show higher arsenic concentrations than the dust sampled in 1993. First, the house dust sampling protocol used in 1993 is not clearly known nor is the amount of large particles (e.g. hair, rocks, glass) removed from the sample prior to analysis. Second, the 1999 houses were uniformly concentrated near to the remediated area while the 1993 houses were distributed throughout Wells. Finally, the 1999 samples were intentionally collected during September, the time of year with the most potential for transfer of soil to the houses. In 1993, the dust was collected in early December when snow cover or frost limits the amount of soil moved into houses.

The 1999 study concluded that the levels of arsenic sampled in the soils were not statistically different from those collected in 1993. The dust samples, even when the high concentrations from the anomalous houses were removed, still showed roughly twice the arsenic concentrations of the 1993 study. When the carcinogenic risks were recalculated using this new concentration of house dust, the health risk estimates still fell within acceptable risk levels set by the Province of B.C.

Implications for the building industry

This study was designed to evaluate whether the site specific risk assessments and risk management process could provide adequate protection of occupants of residential buildings that are constructed on contaminated sites. The project was only partially successful. The main limitation was that the CMHC project manager and the consultant were unable to interest developers or builders on brownfields to fully participate in the project. This can be attributed to the risk for a developer were they to find that the assessment was incorrect and that the residents were subject to significant contaminant exposures. It would take a unusually confident developer to take that liability risk just out of scientific interest. Most brownfield developments are never monitored for airborne contaminants after construction.

The apartment site at Pacific Place in Vancouver showed that the risk assessment was accurate in effect. There was a small, measurable soil gas infiltration rate, but the level of risk to occupants was negligible due to a low level of pollutants in the soil gas and dilution of contaminants by the parkade air. The arsenic exposure for Wells, BC residents was about the same magnitude as that predicted in the assessment, with individual houses showing minor variations. The fact that there were no new dwellings on that site that could be compared to the risk assessment results makes this example less convincing for builders and developers.

Further details on these two sites can be obtained through communication with the CMHC project manager.

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Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

To find more *Research Highlights* plus a wide variety of information products, visit our Web site at

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